X-RAY IMAGING APPARATUS AND CONTROL METHOD FOR THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority from the Korean Patent Application No. 10-2013-0026200, filed on Mar. 12, 2013, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field

Apparatuses and methods consistent with exemplary embodiments relate to an X-ray imaging of an object.

2. Description of the Related Art

An X-ray imaging apparatus may form an image of the internal structure of an object by emitting X-rays to the object and detecting X-rays having passed through the object.

Because the attenuation or absorption of X-rays varies according to constituent substances of an object, the internal structure of the object may be imaged by using the intensity of X-rays having passed through the object.

When passing through the object, X-rays undergo refraction and interference due to constituent substances of an object, which causes a phase shift of the X-rays. Such phase shift depends on properties of constituent substances. In recent years, technologies for imaging the interior of an object using phase contrast of X-rays have been developed.

X-rays have a greater phase-shift coefficient than an absorption coefficient on a per substance basis. Therefore, there is a need for methods and apparatuses which enable the acquisition of a high-contrast image with minimal X-ray exposure by using the phase contrast imaging.

SUMMARY

Exemplary embodiments may address at least the above problems and/or disadvantages and other disadvantages not described above. Also, the exemplary embodiments are not required to overcome the disadvantages described above, and an exemplary embodiment may not overcome any of the problems described above.

One or more exemplary embodiments provide an X-ray imaging apparatus which estimates quantitative data regarding an object using phase contrast image signals corresponding to a plurality of different energy bands, and provides a user with the estimated data in various ways, and a control method for the same.

In accordance with an aspect of an exemplary embodiment, there is provided an X-ray imaging apparatus to form a phase contrast image, includes an X-ray source that generates X-rays to emit the X-rays to an object, an X-ray detector that detects X-rays having passed through the object to acquire phase contrast image signals with regard to the object on a per energy band basis, and a quantitative data acquirer that calculates approximate quantitative data regarding two or more constituent substances of the object using a relation between the phase contrast image signals on a per energy band basis and quantitative data regarding the constituent substances, and estimates quantitative data regarding the constituent substances by iteratively applying a regularization function to the approximate quantitative data.

In accordance with an aspect of an exemplary embodiment, there is provided a control method for an X-ray imaging apparatus to form a phase contrast image, includes acquiring phase contrast image signals with regard to an object on a per energy band basis, calculating approximate quantitative data regarding two or more constituent substances of the object using a relation between the phase contrast image signals on a per energy band basis and quantitative data regarding the constituent substances, and estimating quantitative data regarding the constituent substances by iteratively applying a regularization function to the approximate quantitative data.

The quantitative data acquirer may judge whether or not the estimated quantitative data satisfies a preset verification requirement to verify reliability of the estimated quantitative data.

The quantitative data acquirer may acquire the estimated quantitative data as quantitative data regarding the constituent substances if it is judged that the estimated quantitative data satisfies the verification requirement.

The control method for the X-ray imaging apparatus may further include judging whether or not the estimated quantitative data satisfies a preset verification requirement to verify reliability of the estimated quantitative data.

The control method for the X-ray imaging apparatus may further include acquiring the estimated quantitative data as quantitative data regarding the constituent substances if it is judged that the estimated quantitative data satisfies the verification requirement.

The control method for the X-ray imaging apparatus may further include estimating new quantitative data by again applying the regularization function to the estimated quantitative data if it is judged that the estimated quantitative data does not satisfy the verification requirement.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and/or other aspects will become more apparent by describing certain exemplary embodiments, with reference to the accompanying drawings, in which:

FIG. **1** is a view schematically showing phenomena occurring when X-rays pass through an object;

FIG. **2** is a view schematically showing acquisition of an X-ray image using X-ray attenuation;

FIG. **3** is a graph showing X-ray attenuation and sensitivity to phase shift;

FIG. **4**A is a view diagrammatically showing internal constituent substances of the breast;

FIG. **4**B is a graph showing attenuation coefficients of internal constituent substances of the breast;

FIG. **5**A is a view schematically showing acquisition of a phase contrast image;

FIG. **5**B is a view schematically showing acquisition of a phase contrast image while an X-ray detector is being moved;

FIG. **6** is a block diagram showing an X-ray imaging apparatus according to an exemplary embodiment;

FIG. **7** is a view showing an external appearance of the X-ray imaging apparatus according to an exemplary embodiment;

FIG. **8** is a view showing an internal configuration of an X-ray tube included in an X-ray source;

FIG. **9** is a view schematically showing a configuration of an X-ray detector included in the X-ray imaging apparatus according to an exemplary embodiment;

FIG. **10** is a graph schematically showing energy bands of X-rays that may be emitted from the X-ray source;

FIG. **11**A is a view schematically showing a configuration of a single pixel;

FIG. **11**B is a view schematically showing a configuration which may separate detected X-rays into a plurality of energy bands;